

MAPPING THE GREAT ATTRACTOR REGION  
IN X-RAYS AND DIFFUSE X-RAY EMISSION —  
A POSSIBLE GALACTIC WIND IN THE BULGE OF M31

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Final Report

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# 1 Introduction

The NASA ADP Program to study the x-ray emission in the direction of the Great Attractor and from the core of M31 has resulted in four papers – three on the Shapley Supercluster which is the dominant x-ray feature in the Great Attractor region and one on the diffuse emission in M31. The results of these papers are summarized below.

## 2 The Shapley Supercluster

The dominant x-ray feature in the direction of the Great Attractor is the Shapley Supercluster which is the densest mass concentration in the local Universe. Below we describe the results of our three papers which summarize our work on the Shapley Supercluster.

1. The first paper “X-ray and Optical Observations of the Shapley Supercluster in Hydra-Centaurus (S. Raychaudhury, A. Fabian, A. Edge, W. Forman, and C. Jones, 1991, MNRAS, 248, 101) is a combined study of the individual clusters in the Great Supercluster surrounding Shapley 8. One of the most interesting conclusions of the paper is that this dense region shows an unusual amount of merging and demonstrates the extensive amount of substructure as evidenced by the x-ray emission compared to the optical Abell cluster survey. This substructure implies rapid evolution of clusters at the present epoch which may explain the recent reports of evolution of the x-ray luminosity function over very modest look-back times (e.g., Edge et al. 1990, MNRAS, 245, 559).
2. The second paper (“Optical and X-ray Properties of the Very Rich Cluster Shapley 8 (A3558)”, J. Breen, S. Raychaudhury, W. Forman, and C. Jones 1992, in preparation) provides a detailed analysis of the x-ray and optical properties of Shapley 8, which lies at the core of the supercluster. Shapley 8 (a.k.a. A3558) is the only southern Richness 4 cluster in Abell’s original catalog (a second richness 4 cluster is included in ACO’s Southern Supplement). The standard IPC processing masks the field of view to 1 square degree, to eliminate regions of high background at the edge of the detector field of view. Unfortunately, this masking also obscures much of Shapley 8’s flux. We reprocessed this IPC field by unmasking, and thereby regaining the full  $75' \times 75'$  field of view. Background and vignetting corrections were applied. Figure 1 shows the IPC image from which the x-ray parameters are derived. Shapley 8 (A3558) lies at the extreme western edge of the field of view. The luminous cluster at the eastern edge of the field of view is A3562 while the emission in the center of the field represents an x-ray selected mass concentration.

We used a model of the surface brightness profile,  $S(r) = S(0)(1 + x^2)^{-3\beta+1/2}$  where  $x = r/a$  and  $a$  is a characteristic radius to derive quantitative parameters. Our fit to the cluster profile gave a core radius  $a = 0.4$  Mpc and  $\beta = 0.6$ . We estimated the luminosity and mass of the hot, x-ray emitting intracluster gas. The x-ray count rate is  $0.35 \text{ counts sec}^{-1}$  (within  $0.8$  Mpc of the cluster center) which converts to flux of  $1.10 - 1.13 \times 10^{-11} \text{ erg cm}^{-2} \text{ sec}^{-1}$  for gas temperatures between  $3$  and  $7$  keV. Hence, the flux (and the resulting luminosity are insensitive to our lack of knowledge of the actual

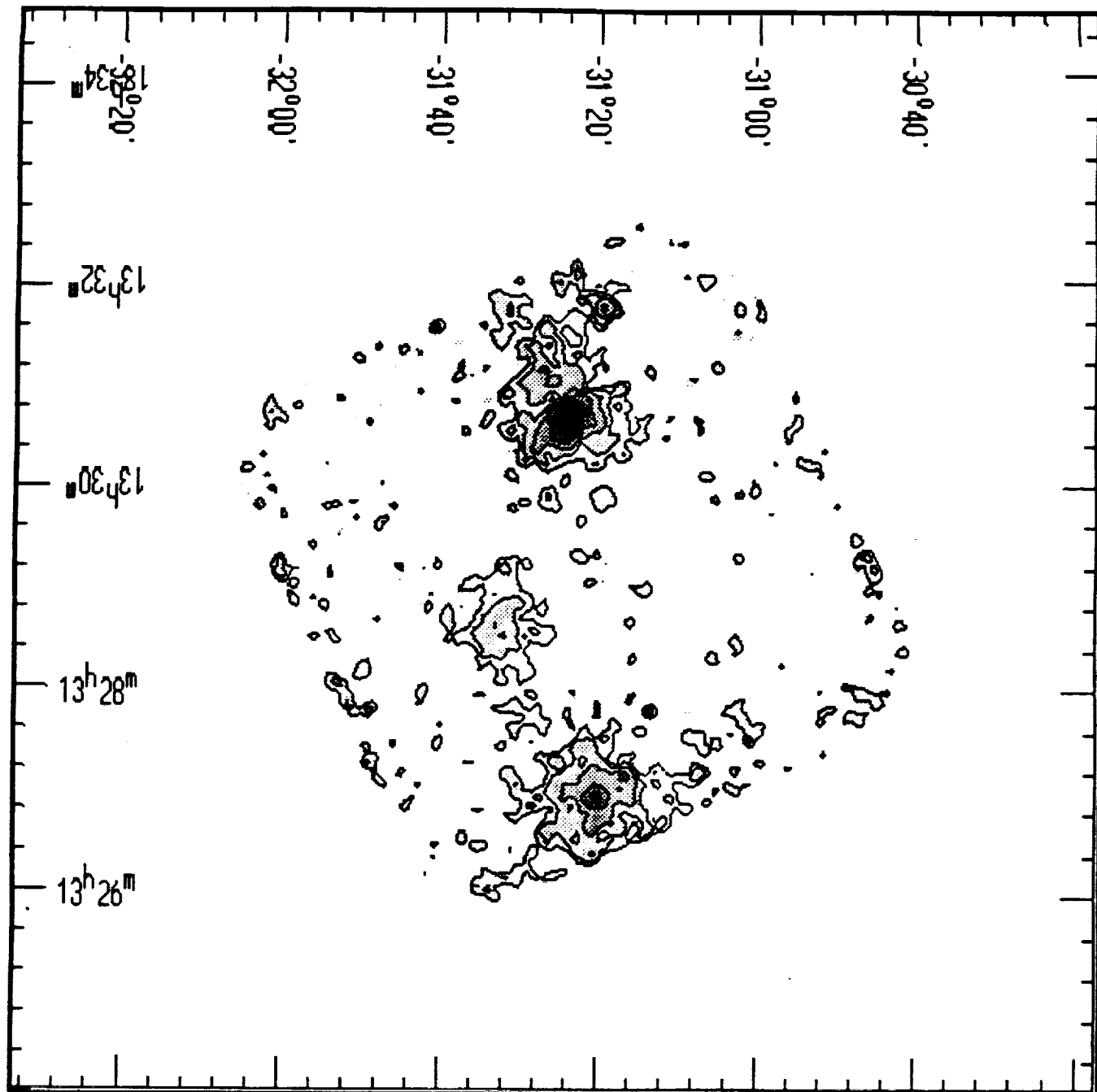


Figure 1 shows the “unmasked” IPC image of the core of the Shapley Supercluster (field of view of  $75' \times 75'$ ). The 0.5-4.5 keV image has been background subtracted and corrected for telescope vignetting. Two optically selected clusters are seen at the western and eastern edges of the field, A3558 (Shapley 8) and A3562 respectively. The extended x-ray emission at the center of the field represents a mass concentration selected in x-rays (but was not identified as a separate system in the Abell Catalog).

gas temperature. The derived luminosity is  $1.12 - 1.16 \times 10^{44}$  ergs sec<sup>-1</sup>, again for the stated range of temperatures. The central density is 0.00087 hydrogen atoms cm<sup>-3</sup>, typical of a luminous cluster and the resulting gas mass is 0.35, 1.1, and  $1.9 \times 10^{14} M_{\odot}$  within 1, 2, and 3 Mpc of the cluster center. This paper compares the gas mass derived from the x-ray observations with the optically luminous mass seen in the galaxies which are members of the cluster.

3. The third paper on the Great Attractor region ("The X-ray and Optical Properties of the Shapley Supercluster", W. Forman, C. Jones, J. Breen. S. Raychardbury 1992) discusses the overall properties of all the clusters in the region. It includes cluster x-ray luminosities, gas masses, optical luminosities, optical masses, and a comparison of the mass in x-ray gas and in optically luminous galaxies for 8 clusters/subclusters which lie in the IPC fields of view in the dense core of the Shapley Supercluster. To map as large a region of the supercluster as possible, we "unmasked" each IPC field of view, extending the field from  $60' \times 60'$  to  $75' \times 75'$ . We generated unmasked background fields which we used to subtract background from each field and applied vignetting corrections. The mosaic of the core of the Shapley Supercluster is shown in Figure 2 and includes 10 extended X-ray sources which are clusters or groups in the supercluster. Table 1 gives the derived x-ray properties of these clusters including x-ray positions, x-ray luminosities (0.5-4.5 keV), and gas masses (to 1 Mpc).

### 3 Diffuse Emission in the Bulge of M31

For M31 we have completed a draft of the paper describing our analysis of the diffuse emission. We derived the radial distribution of the emission and showed that it differed from that of the x-ray source distribution but was similar to the H $\alpha$  emission in the bulge of M31. Since our analysis was performed with the HRI, the conversion from the observed count rate to flux depends on the source spectrum. For a thermal gas with a temperature.  $T = 3 \times 10^6$  K, corresponding to the velocity dispersion of the stellar component of the bulge, the luminosity is  $3.7 \times 10^{38}$  ergs sec<sup>-1</sup> while for a hotter temperature of  $T = 10^7$  K, such as might be expected in a moderate wind from the bulge, the luminosity is lightly less ( $3.2 \times 10^{38}$  ergs sec<sup>-1</sup>). We show that this luminosity is not likely to arise from any known class of objects nor can it arise from the extrapolation of the sources themselves to fainter fluxes than those observed since the ROSAT HRI observations of the M31 bulge show that the M31 log N - log S curve flattens at fainter fluxes. We discuss the implications of the diffuse emission in terms of a wind emanating from the bulge of M31 which also explains the lack of detected cool material which is observed to be shed into interstellar space by the evolving stellar component in the M31 bulge.

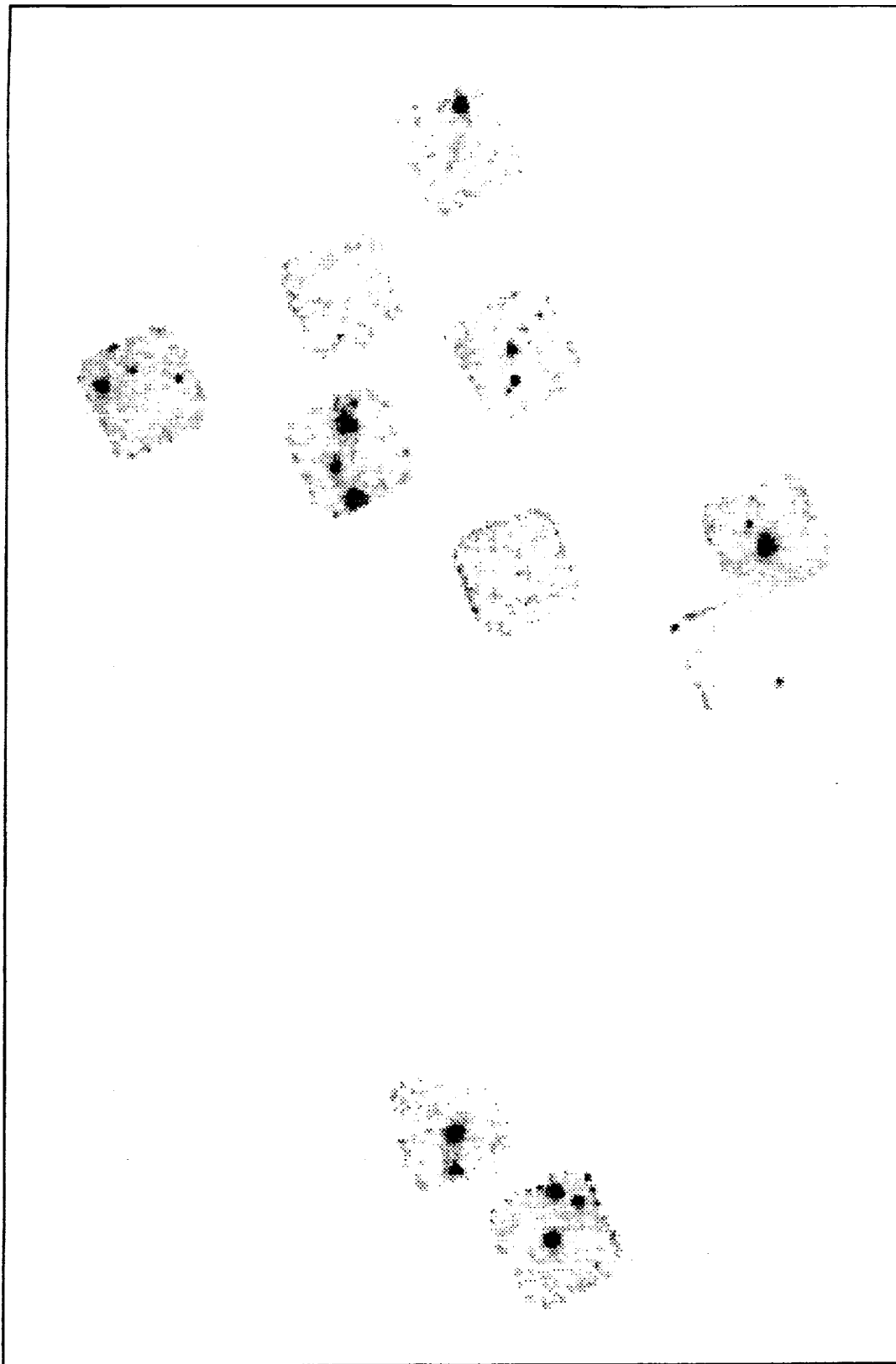


Figure 2 shows the unmasked, background subtracted, vignetting corrected fields in the core of the Shapley Supercluster which lies in the direction of the Great Attractor.